

COUPP E-961 BUBBLE CHAMBER SYSTEM “WHAT – IF” analysis

R. Rucinski 8/6/2009

| WHAT IF | CONSEQUENCE/HAZARD | CONCLUSION/RECOMMENDATION |
|--|--|---|
| The expansion bellows develops a leak? | The pressure differential (time weighted average = 3 psid) favors passing propylene glycol into the bubble chamber volume. The expansion chamber position will start to drift to higher and higher values indicating a problem. Eventually the stop plate bottoms against the shoulder screws and we will lose ability to decompress. If the glycol pressure is lowered quickly, an internal differential pressure of up to 90 psid could develop. The bellows damage could be made worse. | If the expansion bellows fails, the bubble chamber will eventually need to be taken out of service. If the leak is very small, we could consider a modified program with decreased data taking time to keep the volume within an operating range. We have a spare bellows but turn around to data taking could be several months. |
| The outer vessel develops a leak? | A small leak, up to about 0.15 gpm can be overpowered by the small hydraulic pump drawing from the 10 gallon bladder storage tank until the bladder tank is empty and 10 gallons has spilled on the floor. A larger leak will immediately cause an inability to keep or pressurize the bubble chamber fluid. The bubble chamber fluid will expand to fill the volume of glycol lost. At 3.3 liters lost, the bellows will expand and bottom out against the shoulder screws. At that time an internal differential pressure will develop until the large bellows fails (rated pressure = 33 psid) or the pressure holds at 90 psid. Mechanical damage will occur. Turn around on the repair could be months. | A leak and loss of glycol is the most dangerous thing that is most likely to occur. The glycol system will obviously be made leak tight and robust. Mechanical valves are placed directly at the vessel so that leaks (other than on the vessel itself) can be easily isolated and repaired. An operational relief at 300 psig is isolatable and protects against the need for the 400 psig main relief to blow. The main relief is redundant and isolatable by a selector valve. Propylene glycol is environmentally safe. But due to the messy, slippery nature of the substance, secondary containment is recommended. Piping and components need to be protected from damage. |
| There is a loss of house compressed air? | Compressed air is used for fast recompression. Air reservoir tank pressure, PT-7, is interlocked to trigger a fast re-compression on low air pressure <40 psig so the bubble chamber fluid is compressed before all pressure is lost. The interlock is latching so pressure will be maintained. There is a check-valve, CV-73, and pressure regulator that prevents back bleed down of reservoir. Reservoir has enough capacity to re-compress glycol > CF3I saturation pressure = 105 psia, 8 times starting at 40 psig with no air. See calculation that follows. As long as glycol system has no leaks and the temperature remains the same, complete loss of air will result in vaporization of CF3I with a bubble size < 1 cm ³ , bellows travel of about 0.1 inch and system pressure of 90 psig. | The piston position will be nearly bottomed out when the vessel is expanded. |

| WHAT IF | CONSEQUENCE/HAZARD | CONCLUSION/RECOMMENDATION |
|--|--|---|
| There is a loss of electrical power? | The heaters will power off. There will not be a control system. EV-8 will trigger a fast recompression and keep pressure on the glycol system by air pressure. In a long duration power outage, the system could start cooling from the operating point of 40 C to room temperature. The cylinder travel can compensate for 5 C or at most 10 C of cooling off. After that, the pressure will start decreasing to the saturation point of the CF3I. CF3I vapor will accumulate at the high point of the bubble chamber above the water volume. Final pressure of the bubble chamber and glycol system will be 47 psig at 20 C. | System is in a safe configuration without risk of mechanical damage (assuming no significant glycol leaks) with no electrical power. Recovery will involve re-compression of the system via the recompression cylinder and hydraulic pump drawing liquid out of the diaphragm tank. The CF3I vapor will condense and sink through the water, stratifying back with the rest of the CF3I liquid. |
| The hydraulic pump fails to turn or pump fluid? | The pump's primary purpose is to compensate for volumetric change due to temperature change and secondarily for leaks. A temperature change from ambient pressure at 0 C to 50 C compressed corresponds to volume change of 5.4 liters. Without a pump, pressure control will be controlled by the fast recompression cylinder only. The cylinder has a maximum volume change of 1.65 liters (using it's full 8" of travel). 0.6 liters of change is required to go from a decompressed to compressed state. Being conservative, the cylinder would have 0.5 liters available to compensate for a 5 C reduction of temperature or 0.5 liters loss of glycol by leakage. As long as the temperature stays stable or there are no leaks, the system will act normally. Beyond that, see loss of electrical power “what if” scenario. | System is safe from mechanical damage. Temperature changes occur slowly. Propylene glycol can be added into the system manually during a cool down without a functioning hydraulic pump. The 2 kg COUPP bubble chamber is operated in this way. |
| We need to move the chamber when full and operating? | The system can be cooled down and reach equilibrium temperature while pressurized to 200 psig. Then the manual valves closest to the outer vessel are closed. The system should maintain pressure assuming there are no leaks. There will be some amount of dissolved gasses in the glycol that will help keep pressure up. For a planned move, a charged cylinder at 200 psig can be connected to MV-15. | No problem. Only water in the water tank needs to be drained. |

| WHAT IF | CONSEQUENCE/HAZARD | CONCLUSION/RECOMMENDATION |
|---|--|--|
| An operator makes a procedural error? | Upset of the system may occur in most cases. During a fill or transfer of CF3I operation, an operator can potentially release enough CF3I to exceed the ACGIH level of 0.4%. The operator would likely reclose the valve causing the release right away. Most other errors would in a worst case scenario bleed glycol out of the system. Multiple valves would need to be opened to accidentally release glycol. Valves leading directly to atmosphere are capped. An immediate loss of up to 3 liters of glycol can be tolerated, which is enough such that the operator should realize the mistake. | Failure of components are covered in the FMEA. A single operator error can be considered as a failure of the component in one state or the other. An operator can cause a safety problem by directly venting CF3I so a written procedure and second person checking actions is recommended. All other mistakes can possibly lead to mechanical damage to the bubble chamber. |
| The camera fails? | The water tank will need to be drained in order to access the camera. | The cameras should be robust. They are amply cooled by forced air. |
| The camera enclosure develops a water leak? | Water will infiltrate the enclosure. There is a contact type leak detector that will sense the presence of water. There is also a humidity probe that should alert us to the problem. Small water leaks will probably be evaporated by the 30 cfm blower that supplies cooling air for the camera. | A 3/8” plastic tubing line is secured into the bottom of the enclosure. It can be used to pump out accumulated water before it rises to contact the electronics. |